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COLUMBIA RIVER ENTRANCE CHANNEL DEEP-DRAFT VESSEL MOTION STUDY.--ETC(U)
SEP 80 S WANG. M KIMBLE, C BUTCHER, G D COX DACW57-78-C-0028
TETRAT-TC-3925-APP-B-K AD-A098 986 UNCLASSIFIED 1 or 3 AD A

# LEVEL D

COLUMBIA RIVER ENTRANCE CHANNEL DEEP-DRAFT VESSEL MOTION STUDY

FINAL REPORT

AD A098986

APPENDICES B, C, D, E, F, G, H, I, J, K

SELECTE MAY 15 1981

TETRA TECH REPORT NO. TC-3925



DISTRIBUTION STATEMENT A

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SEPTEMBER 1980

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) READ INSTRUCTIONS REPORT DOCUMENTATION PAGE BEFORE COMPLETING FORM 2. GOVT ACCESSION NO. 3. RECIPIENT'S CATALOG NUMBER AD-40989 TITE (and Subtitle) 5. TYPE OF BEFORT Final Repart Deck 78-Sep 80, Columbia River Entrance Channel Deep-Draft 6. PERFORMING ORG. REPORT NUMBER Vessel Motion Study, Final Report Appendice Litetra Tech Report #TC-3925-AUTHOR() B. CONTRACT OR GRANT NUMBER(a) Shen' Wang DACW57-78-C-0028 ≠ Michael Kimble Chris Butcher Glenn D./Cox PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PERFORMING ORGANIZATION NAME AND ADDRESS Tetra Tech, Inc. 630 N. Rosemead Blvd. 12:00 91107 Pasadena, CA 11. CONTROLLING OFFICE NAME AND ADDRESS September 1980 Department of the Army Portland District, Corps of Engineers, NPPEN-PL-2 NUMBER OF PAGES Approx. 1,000 P.O. Box 2946, Portland, Oregon 97208 16. SECURITY CLASS. (of this report) 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office) Unclassified DECLASSIFICATION DOWNGRADING 16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited. 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) 18. SUPPLEMENTARY NOTES Presented at ASCE National Convention, 14-18 April 1980 in Portland, Oregon. (Preprint 80-160). 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Ship Motion, Water Wave Action on Ships, Approach Channels, Entrance Channels Columbia River. 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A prototype ship motion monitoring program was initiated by the Portland District U.S. Army Corps of Engineers to provide design criteria for the entrance channel at the mouth of the Columbia River. The contractor's field team boarded deep draft vessels bound to or from the Columbia River and measured vertical acceleration (heave), pitch, roll, yaw, and position as the vessels transited the 5-mile entrance channel. Twenty-nine vessels were monitored in the period May 1978-March 1979, and twenty-four in the period October 1979-April 1980.

DD 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

#### SECURITY CLASSIFICATION OF THIS PAGE(When Date Entered)

The final report details the field work data reduction processes, analyses, and results. The raw data is used to calculate vertical motions at the bow, stern, and side of the vessel, and the horizontal motion as the ship transits the entrance. This information is evaluated with respect to environmental conditions and the channel. Results of statistical analyses are shown for characteristics of individual transits, and long-range entrance usage.

Appendices A-K contain the tabulated and plotted motion data, environmental conditions, ship motion variables, and other information collected.

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APPENDIX B
INSTRUMENTATION SPECIFICATIONS

SELECTE MAY 15 1981

DISTRIBUTED IN STATEMENT A

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#### QANTEX TAPE DRIVE SPECIFICATIONS

MEDIUM..... 3M DC 300A Data Cartridge COMMANDS..... Write, Write Tape Mark, Erase, Read Forward, Read Reverse, Space Block Forward, Space Block Reverse, Space File Forward, Space File Reverse, Rewind, Unload and Eject. COMMAND CHAINING.... Available for Read and Space Block Commands DENSITY...... 1600 bpi, phase-encoded TRANSFER RATE..... 6000 bytes per second at 30 inches per second READ-WRITE SPEED.... 30 inches per second REWIND & SEARCH SPEED..... 90 inches per second COMPATIBILITY..... ANSI & ECMA Standards HEAD TYPE..... 4 track Read-After-Write POWER...... 110V/60Hz or 105-235V/40-440Hz (Option 01) SIZE...... 21"x17"x7½" WEIGHT..... 29 lbs. (2710-1D), 34 lbs (2710-2D) DATA CHECK..... Cyclic Redundancy Check Character

•	GINBAL FALEDON		7.0	ENVIRONMENTAL SPECIFICATIONS	
•	imit Großa.	2 86 - HIMINUM	7.1	1. 201. 01 1.05-	
~	Guila GIMBAL	360" CONTINUOUS	1.1	ALITIUDE	
•. •.	OUI TAN		1.3	VIBRAT. OH 5 10 500 HZ, 0.036 IMCH 0.A. OR SC	
7.7	Pickast	POTENT IONE TER		MHICHEVER IS THE LIMITING VALUE	
2.1.2	AESISTANCE	\$000 ONHS 1 10K	7.4	HUNIDITY AT 90°F	
2.1.2	POUL BISSIPATION	0.5 WATIS HAXIMUM	1.5	SEALING. SEALED	
97.0	SPIN MOTOR		<b>9</b> .0	ACHANKS	
1.1	VOL JAGE	115 VAC 210K. 400 HZ 25K, 1 PHASE	 	ITEMS MARKED WITH (*) AME CHECKED IN PRODUCTION TESTS. OTHER ITEMS FOR REFERENCE	ERENCE.
2.5	CURACIA	100 MA MAKIMUN STARTING, 65 MA		MAY DE CHECKED ON CHOER BY QUALIFICATION TESTS.	
		MAXIMUM RUHHING	<b>B</b> .2	INSTRUMENT WEIGHT	
1.1	TIME TO SPEED	2 MINUTES NOMINAL WITH BOX OF			
		RATED VOLTAGE APPLIED			
4.0	RRECTION				
;	Injun.	100 MA NOMINAL, INTERMITTENT.			
		INTERNALLY CONNECTED WITH HOLOR			
•5.0	1,140				
5.1	SCORSOT	MOT MORE THAN 10"/HOUR			
		(SCOMSBY DEFINED AS ALTERNATE			
		CLUCKWISE AND COUNTERCLOCKWISE			
		17.5" HOLL, PITCH, AND YAM MOVEMENTS			
		. AT 6.0 CYCLES PLR MINUIE)			
\$.2	MEADING	00 150 0 1 10 0 - 159 0	•		
		(NON-SHORTING GAP IN POLENTIONETER		-	
		1.0* 10 2.0*).			
• •	INSULATION RESISTANCE	20 MEGOIMS, ELECTRICAL CIRCUITS TO CASE			
		WITH SUB YOU APPLIED			

Hounghing VI

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SPECIFICATIONS

٠. ١.	MENANICAL LIMITS	BS. NINIMUM PREEDON OF ROTALION AROU!	\$-00' 01 \$-0
		PITCH ACIS, 160' ABOUT MULL AKIS 6.1	ALTITUOE
•	27.73		3) 40 4 4 44 60 61 7
7.	PICKOFF	PUTENT LUMETER QUIPUT PROPORTIONAL 6.3	ALBANICA ST. 18 LESS WHICHER'S IS LESS WHICH AS A ST. A. S.
		PLACEMENT ABOUT THE ROLL	SW
		AND P11CH AX15.	
~ ~	NOLL ELECTRICAL DISPLACEMENT	.250. 13.	INSULATION RESULTANTE
4.3	PHICH ELECTRICAL DISPLACEMENT	.190, 11.	TOTAL TOTAL CONTRACT TO THE STATE OF THE STA
•	ACSISTANCE	\$.000 15% OIMS	FINISH FINISH
<b>\$</b> 7	MESOLUTION.	O.2 MARINIM	ANDOILE), AND MOUNTING PLAIR (SIAIMLESS SIELE)
3.6	LIMEABILT	D. SX OF FULL RANGE	MEIGHT SAN IMMA
1.1	POWIN DISSIPATION	•	SAUCH DOS
•	CONIDCT AFSISTANCE	100 GINS EQUIVALENT CONTACT RESISTANCE	
		PER N.A.S. 710 7.0	AEMARKS
9.6	ELECTALCAL REQUIREMES	1.1	ITENS MAKED WITH (*) ARE CHECKED IN PRODUCTION IESTS. DIMEN ITENS FOR REPARTMEN
1.7	VOLIACE	21. VOC + 200	MAY BE CHECKED ON DROEM BY QUALIFICATION 16515.
7.7	CURRENT	1.5 AMP NOHINAL	
9.	SPIN MOTOR AIRD ERECTION SYSTEM TIROUGH INTERIAL INVERTER	MIERIAL INVENTER	
ij	VOLIAGE	115 VAC. 400 HZ. SINGLE PLASE	
7.7	CURRENT (RUMAING)	110 MA MORINAL	•
7	CURRENT (STARTING)	350 MA HUMINAL	
4.	TIME TO SPEED	MINUTES PARTMENT	
<b>~</b> ;	ERECTION RATES		
1.5.1	11M 10 (A(CI	HINUIES MAXIMUM TO WITHIN 1.0"	
		OF VERFICAL AFTEN POWER IS APPLIED	
		UNDER STATIC CONDITIONS. 6 MIN. DYNAMIC CONDITIONS.	•
4.5.1	MUNINAL ERECTION RATE	ROLL 7'/HIM	
		PIICH 3'/MIM.	
1.5.3	VERTICAL ACCURACY	10.1" OF IRUE VERTICAL	
5.0	ACCELERANGIER		
•\$.1	Aunci	11.06	•
2.3	INPUT	JA VOC FROM IMPUT VOLÍACE (IMJERNALLY REGULATED)	
	Although Sale Today	1.504/6	
:	ACCURACY (INCLUDING HYSIFRESIS AND REPEATABLETY	3.1% OF FULL SCALE	
5.5	Stif fts1	CHARINI TONGUING CAFABILITY FOR CALIBRATION	
		L54 LA.	

- handwall &

SECONETE .- C

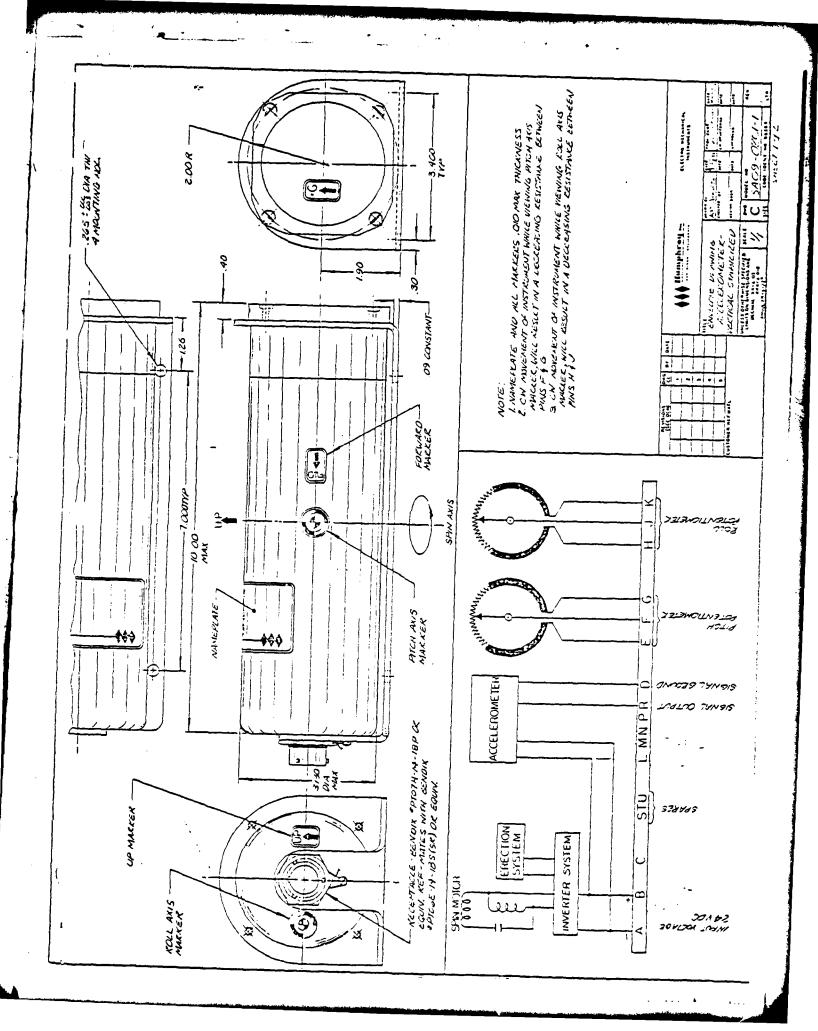
C. SAMOZOVI

## SPECIFICATIONS

9.	PECIANICAL LIMITS	185" HIMIMM PREEDON OF ROTALION ANDUI	L NV I ROMJE NTAL	
		PIICH AA15, 360" ABOUT RULL AXIS 6.1	TEMPERATURE 0'F 10 +110'F	10.1
0 1	17.03	7.7	ALLITUOE . 1000 10 40,000 FF.	
7	PICKOFF	POIEMI LONETEN GUIPUL PROPONTIONAL 6.3	VIBALTION S 10 500	5 10 500 HZ AT 0.036 0.A. OR 56
		AOLL	MH: EHEVER IS LESS	15 4655
		AND PIECH AKIS.	SHOCK 306 ALL A	20G ALL ANÉS 10 21 MS
~	MOLL ELECTRICAL DISPLACEMENT	\$:90, #3.	INSULATION RESISTANCE	20 MCOWNS AT 50 VOC BEIMEEN ISOLATED CIRCUITS
7.7	PITCH ELECTRICAL BISPLACEMENT	150. 15.	AND CASE	
\$.7°	RESISTANCE	5.000 15% Ouns	FINISH MOUNTING	MOUNTING BASE (BLACK EPONY), CASE (BLACK
2.5	AC SOLUTION			ANDDIZE), AND MOUNTING PLATE (STAINLESS STEEL
3.6	LINGARITY	D. SX OF FULL RANGE	THE ACTION S	: :
1.1	POMÍN GISSIPATION	O.S WALTS		
7	CONTACT RESISTANCE	200 OHMS EQUIVALENT CONTACT RESISTANCE 6.8	SERVICE LIFE SOO HOURS	
		PER H.A.S. 710	ALMARIS	
9.	ELECTRICAL MEQUIMEMENTS	1.1	ITEMS MARKO HITH (*) ARE CHECKED IN PHODUCTION IESTS. GIMLA ITEMS FOR ALFERENCE	OTHER TIENS FOR REFERENCE
7.7	V011A:£	24 VOC + 24K	MAY BE CHECKED ON DROER BY QUALIFICATION TESTS.	
3.2	( nate)	1.5 AMP NOMINAL		
و	SPIM MUTOR AID ERECTION SYSTEM TIMOUGH INTERNAL INVERTER	HIERIAL INVERIER		
;	YOL IACE	STATE STATES STATES		
~	CURRENT (RUNAING)	THO MY MOULE		
7	COMPLET (STATISTICS)	DOG FA HUMINAL		
		מייייייייייייייייייייייייייייייייייייי		
?	INICION ADIES	•		
4.5.	TIM TO INICE	MINULES PARTHUM TO MITHIN 1.0"		
		OF VENTICAL AFTEN PUMEN IS APPLIED		
		UNDER STATIC CONDITIONS. 6 MIN. BYMANIC COMPITIONS.		
4.5.3	MUNINAL ERECTION RATE	ROLL 7'/HIM.		
		PIECH 3º/HIM.		
4.5.3	VERTICAL ACCUMACY	10.2" OF TRUE VERILCAL		
9.6	ACCELERONG TER			
•	PANG	1.06		
7.	INPUT	(INIGHALLY REGULATED)	•	
. 5.5	OUTPUT SENSITIVITY	2.504/6		
<b>:</b>	ACCURACY (INCLUDING HYSIGRISIS AND REPERTABLLITY	3.1X OF FULL SCALE		
\$.5	Stuf 16st	C'ANEME TONGUING CAPABILITY FOR CALIBRATION		
		CHELA.		

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C SACTORIO CON INC.



APPENDIX C
SAMPLE DATA SHEET FROM VOYAGE NO. 9

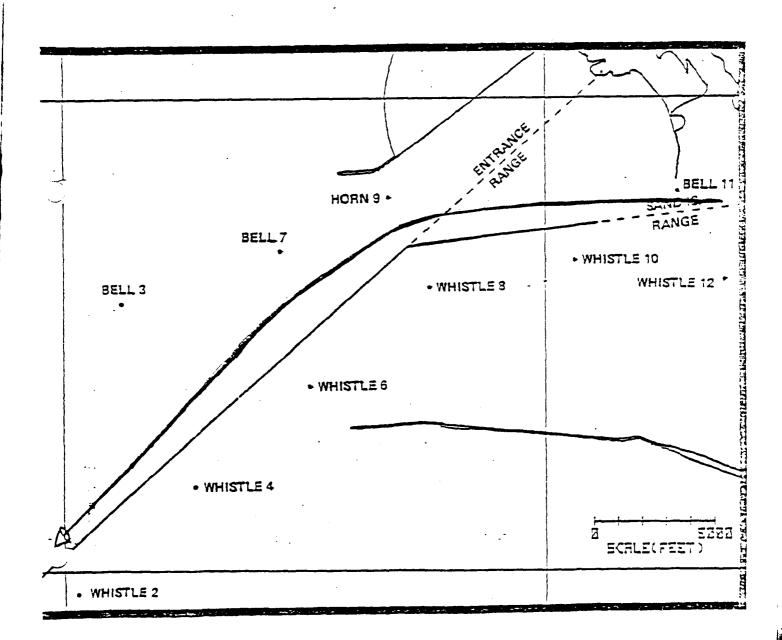
		VOYAGE NO		<del></del>	
I.	VOYAGE DESCRIPTION				
••	Route: From	u. 32.5c	•	To [	) ( - + = 1
	Dates: Depart /S		1		
	Time Zone Description _				
	Tt Personnel			_	BUTCHER
II.					
•••	Name CHEVEN WA	1016	Type C	. Can e .	۷.
	Captain S-EVE ALEVA				
	LOA (51'4"				
	<u>Draft</u> : Fwd			1000/	
	Aft 30'0	ļi			
•	Mean23'4'		Displacemen	t 34 38	35 LT
III.	CG AND SENSOR LOCATIONS			4	
		Z		7 (- 4	
	4.	A. P.			· .
		X	Υ	Z	COMMENTS
	Motion Sensor	103.4	+3,25'	100.7	uni Cade - to LE Sus
	Mini Ranger R/T	93.3'	+ !.25'	1235'	DE JEST SAILING DE 155
	Fathometer Transducer	596'	_		Thene Juck whe fow
	LCB (from Hydrostat Data)	324.4	-	-	
	LCG (computed)	313.9	-	_	
	VCG (computed)	-	-	22.6	
_IV.	BAR CROSSING				
	Date 4 Hovember 191	-3	Time	0856-	0919
	Bar Piloton & Mcana				
	Pilot's Opinion of Crossing	,	,2 <u>5</u> ¥		
		and the second second	الله هندي المراجع المر 		

Voyage \_\_\_\_

Recorder \_\_\_\_\_

Page 1 / 10

		Voyage 9  Recorder 2 10
	TRAN	SIT LOG
Begin_ 0356	4 NON/79	End <u>0919</u>
Bar Pilot <u>C                                </u>	C. Mc ALDIN (No	11) Opinion of Crossing Easy
Cassette: Number	<u> </u>	Side A
Start	033	Stop 071



			Voyage Recorder	
·	ORSER	YATIONS		3/10
- I Tinec			Ti wa	<b>77</b>
I. TIDES	Time	Elevation (ft) -2.4 لصد	<u>Time</u> 1 <u>5</u> 19	Elevation (ft) + 3.7 HIGH
Astoria(Tongue Point)	- 1 <sup>h</sup> 10 <sup>m</sup>	+0.1		<u>-0.7</u>
Correction		+2.5 Com	<del></del>	+ 8.0 High
Entrance(North Jetty)				<del>+ 0.0   +14+</del>
Corrections on Astoria:	•	r -0 <sup>h</sup> 46 <sup>m</sup> -0.7 -1 <sup>h</sup> 10 <sup>m</sup> +0.1		
II. TIDAL CURRENTS	Time	Current (Kt)	Time	Current (Kt)
Grays' HbrEntrance	0628	2.4633	0922	Schole
Correction	+0"20"	x 1.5	+0,05	
Entrance (Buoy No. 12)	0648	3.6 66	0927	SLACIE
III PRE-RUN OBSERVATIONS  Time: 0350	Max. Curr	ent +0" 20" F1	ood Ratio 1.4 E	bb Ratio 1.5
Weather: Gir	<del></del>		<del> </del>	
Temperature: 43° E	<del></del>	Visibility:_	<u> </u>	<del></del>
Wind: NW 10-	15 KN 673	·	· · · · · · · · · · · · · · · · · · ·	
Sea State: Seas: <u>ಗಳ</u>	W/ND CHO!	Swell	N.S	
	<u>-                                    </u>		<del></del>	
IV. POST-RUN OBSERVATIONS	•			
Weather: FAIR			•	
Temperature: 56° F	-	Visibility:	ÜNCIMITES	
Wind: UW 15km		-		
Sea State: Seas: ハѠ		Swell	12/2/4/	
2-4		_	10-12'	
-		_	1034	

Voyage _	9	
Recorder	CB	
Page	1 /	10

#### OBSERVATIONS DURING RUN

NOTE: Observations are to be recorded approximately every 2 minutes or when course and/or speed changes or other noteworthy events occur.

		SHIP				
TIME	Course °T	Speed Kts	Pitch/RPM Ft/RPM	Honomert Gans		EVENT / COMMENT
1777 1776	275	14rZ	16	278.8	3.3 W	
0358	265	14.5	16	272	7 W	
0900	253	14.8	16	258	574	
<u>,                                    </u>	255	13.8	15	258.5	),5W	
<u>~~~</u>	\$ 230			235.4	5.4W	
0907	227	13.1	15.5	231, 8	4.8 W	
0909	220	13,2	15.5	222.4	2.4W	
<u> 1911</u>	221	12,7	15	223	2 W	
<u> 0213 - </u>	218,5 1	12.4	15,5	219	,5W	
0915	222	1210	15	224.9	2.9W	
0918	220	<i>[3.]</i>	15	221.8	1.8W	
STS 2 0919 05 ,						
_						
	·	100 00		11 856	11 - FRIJE 30	

1 15 1 D Dez

3.21 AFT TO CONTRIVE OF ME

Voyage _		1		
Recorder		کی		
Page	5	_ /_	10	

#### INSTRUMENT CHECK & CALIBRATION

		Pre-Run	Post-Run	Comments
I.	TAPE HEADS			
	Clean HP Tape Head	/		
	Clean Qantex Tape Head	/	_	
II.	PITCH			
	Leve?	/		
·	+45° (Down by Bow)	./		
	-45° (Down by Stern)		/	
ITI.	ROLL			
	Leve?		/	
	+45° (To Port)	/	/	
	-45° (To Starboard)	/	/	
IV.	HEAVE	,		·
~	Rest	1.		
~	Positive Acc. (Up)		/	
	Negative Acc. (Down)		/	·
٧.	HEADING	· 	•	
•	Time	0842	0930	SHIPS GAR DENIATION: 1.2°E
	Gyro (°T)	315.5	161.9	
	Corrected Ship's Gyro (°T)	315.5	160.0	
	Deviation	-0-	1-9° W	Drift Rate: 1.7 70 435
VI.	MINI RANGER	_		
	Byte Test Card Check		/	New Station@ CARE ) LEUKS OK
VII.	SYSTEM TEST	•		
	Record on Qantex &			
•	Playback:			
11.	OBTAIN COURSE/RUDDER ANGLE RECORD			
- τχ.	OBTAIN FATHOMETER RECORD			
				<u> </u>

#### VOY #9 PRE RUN CHECK

Pitch= 000.0dea
Roll=-000.5dea
Rocel= 1.003Gs
Hdna= 255.7dea
A Sha=99799994ds
Fime: 00:07:21

Pitch= 045.5dea Roll= 008.6dea Accel= 1.003Gs Hdna= 255.4dea A Rna=???????yds B Rna=???????yds Time: 00:07:37

Pitch=-045.2dea Roll=-002.9dea Accel= 1.003Gs Hdna= 255.3dea A Rha=???????yds B Rha=??????yds Time: 00:07:52

Pitch= 001.1des Roll= 044.7des Hocel= 1.005Gs Hdns= 254.9des H 2ns=???????yds B 2ns=???????yds Time: 00:08:16

Fitch=-002.9dea <u>9011=-046.1dea</u> -Accel= 1.003Gs Hdna= 254.8dea 8 Rna=???????yds B Pna=??????yds Time: 00:08:24

Pitch= 001.1de# Roll=-011.4de# Accel= 1.628Gs Hun== 253.3de# A Rn==???????yds B Rn==???????yds Time: 00:09:16

Pitch= 014.9dea Roll= 012.2dea Accel=-0.295Gs Hana= 253.5dea A Rna=??????yds B Rna=??????yds Time: 00:09:29 YOYAGE # 9

PRE RUN EQUIPMENT CHECK

VOY #9 QANTOL PLAY BALL

Pitch= 000.0dea Roll=-000.3dea Accel= 0.999Gs Hdna= 246.3dea A Rna=??????yds B Rna=??????yds Time: 00:14:30 301

Pitch= 000.0dea Roll=-000.9dea Accel= 1.003Gs Hdng= 246.2dea A Rng=??????yds B Rng=??????yds Time: 00:15:27 201

YOY#9 THE PLANGACE

#### THE PLU CHECK VOY #9

Proch= <u>901.1dea</u>
Poll= <u>909.3dea</u>
Rocel= <u>0.342</u>Ga
Hdna= 189.1dea
A Pha=014136 da
Time: 09:39:05

Pitch= 045.6dea Roll=-002.2dea Rocel= 0.994Gs Hdna= 189.4dea A Pha=016742yds B Rha=014364yds Time: 09:39:40

Pitch=-044.9dea Poil=-001.9dea Rocel= 1.059Gs Hung= 139.0dea R Rha=0167427ds B Rha=0144447ds Time: 09:39:54

Pitch=-001.6dea Poll= 044.8dea Accel= 0.961Gs Hdna= 139.1dea A Rna=0167427ds B Rna=0145067ds Time: 09:40:04

Piton= 000.8dea Poll=-045.4dea Accel= 1.003Gs Hdne= 138.7dea A Rha=015742Yds B Rha=014553Yds Time: 09:40:11

Pitch=-005.5dea Roll= 000.4dea Accel= 1.314Gs Hdn== 189.5dea A Rn==016999yds B Rn==014645yds Time: 09:40:25

Pitch= 015.2dea Roll= 025.6dea Accel=-0.307Gs Huna= 189.9dea A Rha=016399yds B Rha=014633yds Time: 09:40:30

## VOYAGE #9

POST RUN EQUIPMENT CHECK

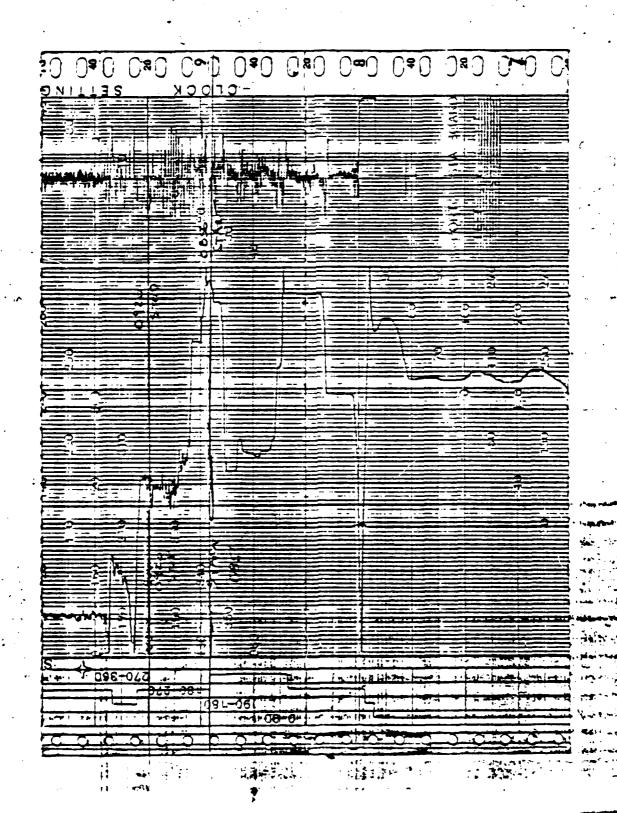
	EDITED '	THPE	ZESULT
	VOYAC	E#	
	4 ±00 09094		<b>.</b> •
POST RUN THE PLAN SACE	5 300 29094		1.
vov 45 9 Piton= 000.1des Roll=-000.9des Accel= 1.003Gs	4 400 89894		<b>4</b> • A · G
Hdng= 279.0deg A Rng=009278yds B Rng=002490yds	6 sca 09094		ı •
Time: 08:56:00 801 Pitch= 000.4des	4 sco 09094		11
Roll= 000.5des Accel= 0.968Gs Hdns= 216.1des	8 sco 09095		a t
A Rng=015345yds B Rng=009855yds	4 sco g9g95	-	a *

file mark

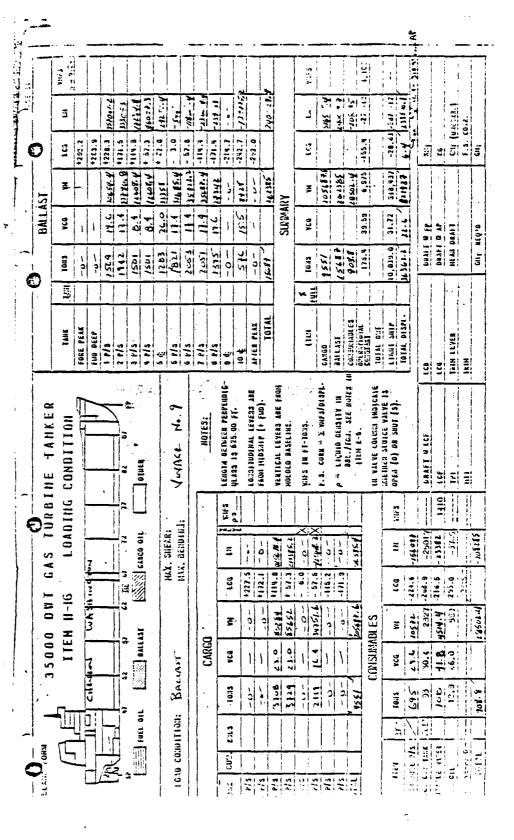
Time: 09:19:02

EOT

# Course de Proper Angle Riches Voyage No. 9



	FATHOMETER VOYAGE NO	Record	/ Soundings	14"
· · ·	VOYAGE NO	. 9	FT. BELOW	Keie
		9	08	8
820	9.0	-860	<b>3</b> 80	
			8	
				33
			S S V S S V	
	topicial in a second	A PARTY OF THE PAR	La L	



APPENDIX D
SUMMARY OF STABILITY CRITERION FOR PHASE II VOYAGES\*

\*Computed from available information provided by the ship's engineering officers

## SUMMARY OF STABILITY CRITERION (Phase II Only)

VOYAGE NUMBER	TRANSVERSE METACENTRIC HEIGHT ${\sf GM}_{\tau}$ (ft)	LONGITUDINAL METACENTRIC HEIGHT GM <sub>L</sub> (ft)
30	12.3	922.8
31	21.9	1126.0
32	7.3	798.3
33	14.7	989.3
34	12.9	957.5
35	4.4	893.2
36	2.7	675.1
37	14.0	1098.6
38	17.9	1039.9
39	12.2	913.8
40	21.0	1104.0
41	2.7	891.3
42	3.3	649.6
43	7.6	880.1
44	8.3	922.3
45	15.2	956.6
46	11.5	948.6
47	4.3	865.3
48	7.7	926.5
49 <sup>Δ</sup>		
50	15.2	930.2
51	2.5	648.7
52	6.3	821.4
53	18.6	1027.3

Δ Data unavailable

#### APPENDIX E

MONTHLY SUMMARIES OF WEATHER OBSERVATIONS AT CLATSOP COUNTY AIRPORT, ASTORIA, OREGON

MAY, 1978 - JUNE, 1978 NOVEMBER, 1978 - MARCH, 1979 OCTOBER, 1979 - APRIL, 1980

MATIONAL MERTHER SERVICE OFC

CLAISOP COUNTY SIRPORT

## Local Climatological Data

HONTHLY SUMMARY



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- ESTREME FOR THE MONTH LAST DECURRENCE IS MORE THAN DUE. THESE MODULE MLSG OR AM ERRELER DRIFE, 3N DATES, \*\*COMENT FOR \*\*CESSELLET THAN NILE 20 LESS.\*\* \*\*COMENT FOR WIND DIRECTIONS AND THAN 30 LESS.\*\* \*\*COMENT FOR WIND DIRECTIONS AND THAN 30 LESS.\*\* \*\*DRIFE CLUBBLES FROM THE NORTH JO TOUR.\*\* \*\*DRIFE CLUBBLES FROM THE NORTH JO TOUR.\*\* \*\*DRIFE CLUBBLES FROM THE NORTH JO TOUR.\*\*

HOME INSERVATIONS FOR DAN AT 3-MOUR INTERVALS.

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J.S. DEPORTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASMEVILLE, N.C. 28801

POSTROE MIG PEES PAID w.s. permetreur or connece COM - 210



FIRST CLASS

CLATSOF COUNTY ALREORT

## Local Climatological Data

MONTHLY SUMMARY



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Saniel B. Michell 318EC 100. HATTONIAL TENTER

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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING REMEYILLE, N.C. 28801

ME COURL SPESSTURETY EMPLOYER

POSTROE AND FEES HOLD W.S. DEPOSTREET OF COMPRECE COM-210



FIRST CLASS

## Local Climatological Data

HATICHAL HEATHER SERVICE OFC

CLATSOP COUNTY ALRPORT

MONTHLY SUMMARY



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I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE HATIONAL OCCANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE HATIONAL CLORATIC CENTER, ASHERILLE, MORTH CAROLINA, 25801.

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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASHEVILLE, N.C. 28801

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### Local Climatological Data

HATTONAL HEATHER SERVICE OFC CLAISOP COUNTY STRPORT

MONTHLY SUMMARY



DECEMBER 1978

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ENVERONMENTAL DATA AND . NEGRAMICON SERVICE

Carriel B. Mitchell 3196(130). NATIONAL ILLIANS

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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASHEVILLE, N.C. 28801

AN EQUAL DESCRIPTIONETT EMPLOYER

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FIRST CLASS

### Local Climatological Data

MATICNAL MERTHER SERVICE OFC

CLAISOP COUNTY BERPORT

MONTHLY SUMMARY



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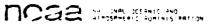
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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASHEVILLE, N.C. 28801

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FIRST CLASS

NATIONAL MEATHER SERVICE OFC

CLATSOP COUNTY REPORT

## Local Climatological Data

MONTHLY SUMMARY



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Seriel & Mitelell DIRECTOR. NATIONAL CLINATIC CENTER

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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC DENIER FEDERAL BUILDING ASHEVILLE, N.C. 28801

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CLATSOP COUNTY ALRPORT

#### Local Climatological Data

MONTHLY SUMMARY



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#### Local Climatological Data

MATIONAL HEATHER SERVICE OFC

CLATSOP COUNTY ALRPORT

HONTHLY SUMMARY



OCTOBER 1979

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U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASHEVILLE, N.C. 28801

AN EQUAL SPRORTUNITY EMPLOYER

POSTROE AND FEES PRID U.S. DEPOSTMENT OF COMMERCE COMMERCE



FIRST CLASS

## Local Climatological Data

NATIONAL WEATHER SERVICE OFC.

SCATSOR COUNTY ALRPORT

MONTHLY SUMMARY

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SUMMARY BY HOURS

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TERTIER THAT THIS IS AN DEFICIAL PUBLICATION OF THE NATIONAL DESANCE AND ATMOSPHERIC ADMINISTRATION (AND 1) COMMISSIONAL COMMISSIONAL AND ADMINISTRATION (AND 1) COMMINISTRATION (AND 1) COMMISSIONAL DEFICE.

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J.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER FEDERAL BUILDING ASHEVILLE, N.C. 28801

AN EQUAL SPORTUNITY EMPLOYER

POSTAGE AND FEES PAID U.S. DEPARTMENT OF COMMERCE COM-210



ASTORIA, GREGON

NATIONAL HEATHER SERVICE OFC

TROPRIA TINUES ROSTAL

# Local Climatological Data

MONTHLY SUMMARY

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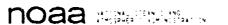
SUMMARY BY HOURS

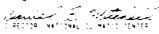
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ASTORIA.

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JUST DEPARTMENT OF COMMERCE NATIONAL CLIMATIC DENTER FEDERAL BUTLOING ASHEVILLE, N.C. 29801

AN EQUAL SPRORTUNETY EMPLOYER

POSTAGE AND FEES PAID

S DEPARTMENT OF COMMERCE

COM-210



ASTORIA, DREGON

Local Climatological Data

NATIONAL HEATHER SERVICE OFC

CLATSOP COUNTY AIRPORT

MONTHLY SUMMARY



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\*\* TRACE HOUSE
\*\*\* ALSO 38 HE EARLER DATE, 38 DATES.
\*\*EANT TOOL \*\*\* ITSTBILLITY '14 MILE 38 LESS
\*\*FIGURES FOR HIMO DISPECTIONS THE TENS JP 3EDATE 3. ALCOUNTSE FROM THE MOST DATE CALM
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MORE JASERVATIONS PER DAY AT 3-HOUR INTERVALS.
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THE ANNUAL SUMMARY.

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SHIMMARY BY HOURS

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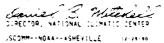
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TERRITOR THAT THIS S AN OFFICIAL PROLUCATION OF THE WATCHAL DEERNIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL DUMBRICO JENTER, ASSESTICAL, MORTH CARDULNA, 19801



ENVIRONMENTAL DATA AND NEGRESCO



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//3. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC DENTER FEDERAL BUILDING ASHEVICLE, N.D. 28801

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POSTAGE AND PEES PAID

PLS. DEPARTMENT OF COMMERCE

DOM-210



## Local Climatological Data

MATIONAL HEATHER SERVICE OFC

SLATSOP COUNTY AIRPORT

MONTHLY SUMMARY



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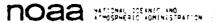
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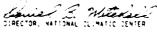
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CENTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL COMPILED SENERALLES NORTH CARDLINA DEBOT.



ENVIRONMENTAL DATA ENO



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POSTAGE AND PEES PAID

1.5 DEPARTMENT OF TOPMENCE

3.5 M = 2 1.3



#### Local Climatological Data

MONTHLY SUMMARY



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LATETUDE 46 \* 39 'N LONGITUDE 123 \* 53 '4 STANDARD "IME USED: PACIFIC 3 67 FLEVATION (GROUNG) MEATHER TYPES SHOW,
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E EXTREME FOR THE MONTH - LAST DOCUMBENCE IF MORE THAN 1966.

"RACE HOUSE!

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FIGURES FOR NAME OBSECTIONS ARE TENS IF DEIMPRES TUDINISE FORM YORK MORE MORTH OF TALK.

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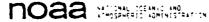
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TERTIFY THAT THIS S AN OFFICIAL PORTLOATOR OF THE NATIONAL DEERHIC AND ATMOSPHERIC ADMINISTRATION, AND S TOMPILED FROM PECORDS ON FILE AT THE NATIONAL CLIMATIC DENTER, ASHERILLE, NORTH CARD, NA 19801



ENVIRONMENTAL DATA AND LANGER

Service Miledelle DIRECTOR, MATIONAL DELIMATED DENTER

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JS DEPARTMENT OF COMMERCE NATIONAL DUIMATIC DENTER FEDERAL BUILDING ASHERICLE, N.D. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID

1 DEPARTMENT OF COMMERCE

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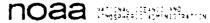
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. 3 DEPARTMENT OF COMMERCE FEDERAL BUILDINA 48-87/LLE N. D. 28901

#### APPENDIX F

DAILY SUMMARY OF WEATHER OBSERVATIONS AT CLATSOP COUNTY AIRPORT, ASTORIA, OREGON, ON DATES OF BAR TRANSITS

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## APPENDIX G

WIND, SEA AND SWELL OBSERVATIONS FROM
LIGHTSHIP COLUMBIA AT APPROXIMATE TIMES OF BAR TRANSITS
(PHASE I ONLY)

SOURCE: S. Noble, U.S. Army Engineer District, Portland, Personal Communication

SUMMARY OF WAVE SPECTRA AND WIND DATA AND PLOTS OF WAVE SPECTRA CORRESPONDING TO APPROXIMATE TIMES

OF BAR TRANSITS (PHASE II AND SELECTED VOYAGES OF PHASE I)

SOURCE: Dr. Lee Harris, U.S. Army Coastal Engineering and Research Center

Note: All wave spectra data is to be considered prelimin ry. Wave spectra data for Voyage Nos. 20, 21, 22, 30, and 31 are from a Waverider buoy which was implanted by the Portland District Army Corps of Engineers near the lightship Columbia. Wave spectra data for the remaining voyages are from the NOAA wave gauge located in the navigational lightbuoy which replaced the lightship Columbia.

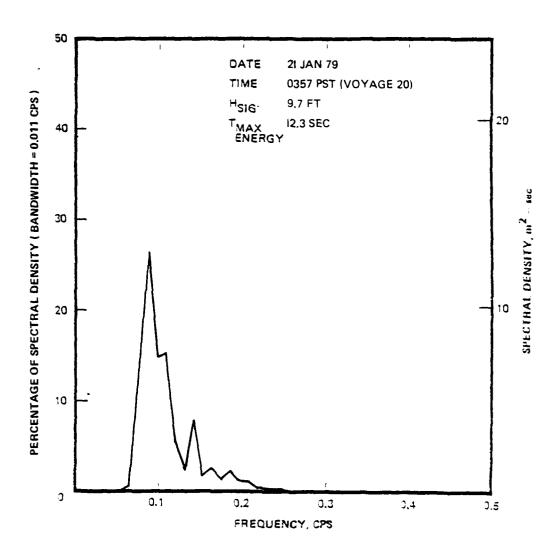
WIND, SEA AND SWELL OBSERVATIONS
FROM LIGHTSHIP COLUMBIA
AT APPROXIMATE TIMES OF BAR TRANSITS

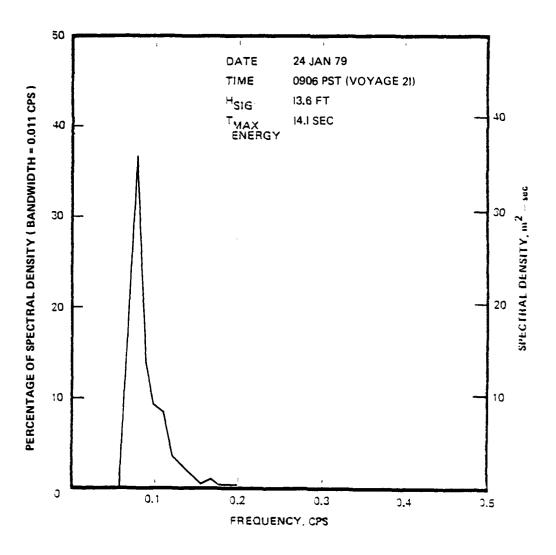
CORRESPONDING			CINIM		SEA			SWELL	
VOYAGE NUMBER	DATE	TIME (PST)	DIRECTION (°T)	SPEED (knots)	HEIGHT (⅓-meters)	PERIOD (sec)	DIRECTION (°T)	HEIGHT (4-meters)	PERIOD (sec)
8	1 Nov 78	1300	310	22	1	2	270	3	9
6	4 Nov 78	1000	50	10	0	0	270	Е	9
10	9 Nov 78	0400	40	15	0	0	270	Ю	9
10	9 Nov 78	0020	50	20	-	~	270	ю	9
11	10 tiov 78	1300	360	22	~	~	270	æ	9
11	10 Nov 78	1600	09	16	-	7	270	2	9
12	28 Nov 78	1300	180	15	0	0	240	2	7
13	Dec	0400	190	17	7	7	270	2	7
13	3 Dec 78	0070	180	25	2	5	240	3	7
14	4 Dec 78	1600	340	27	2	4	290	4	9
15	15 Dec 78	0400	270	11	0	0	270	25	9
15	15 Dec 78	0070	260	6	0	0	270	ស	9
16	17 Dec 78	1300	160	12	2	е	270	9	7
16	Dec	1600	1.40	Z.		m	270	'n	7
17	30 Dec 78	0100	70	16	<b>r</b>	5	280	2	7
18									
19			ONNO	-NO DATA-					
20									
21	Jan	0020	06	12	0	0	270	2	7
2.2	Jan	0400	09	15	0	0	300	4	9
22	Jan	0070	20	12	0	0	280	٣	2
23	7 Feb 79	2200	160	12	0	0	250	e	9
23	8 Feb 79	0100	150	13	7	4	250	٣	9
24	11 Feb 79	1000	180	18	<b>~</b>	K/N	230	٣	7
25	Feb	2200	80	16	7	3	280	2	ပ
26	27 Feb 79	1300	220	6	0	0	240	٣	9
27			- 1	-NO DATA-					
28	Mar	0400	90	6	0	0	300	7	7
29	23 Mar 79	0020	70	10	0	0	330	7	7
29	Mar	1000	10	8	0	0	300	7	7
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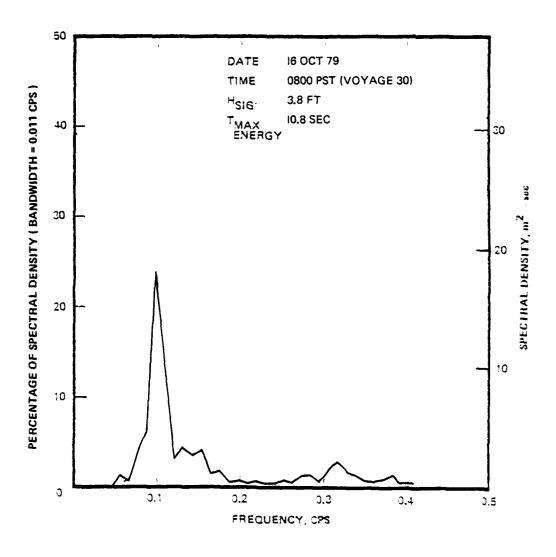
SUMMARY OF WAVE SPECTRA AND WIND DATA

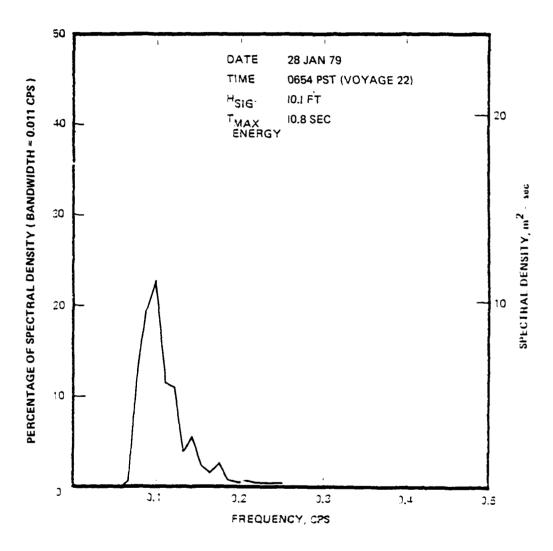
			WIND		WAVE SPECTRA DATA	
CORRESPONDING VOYAGE NUMBER	DATE	TIME (PST)	SPEED (KNOTS)	DIRECTION (°T)	SIGNIFICANT HEIGHT (FT)	PERIOD (SEC)
20	21 JAN 79	0357			9.7	12.3
21	24 JAN 79	0906			13.6	14.1
22	28 JAN 79	0654			10.1	10.8
30	16 OCT 79	0800			3.8	10.8
31	17 OCT 79	1700		<del></del>	9.0	14.1
32	! 					: 
33	14 NOV 79	2000		i 1	3.9	8.3
34	17 NOV 79	2300			7.2	9.1
35	21 NOV 79	0500			9.8	12.5
36	26 NOV 79	0900			7.4	8.3
37	28 NOV 79	2100			7.8	12.5
38	03 DEC 79	1400	!	i !	12.6	7.7
39	16 DEC 79	0800	i ;	<u></u>	4.3	9.1
40	18 DEC 79	0900	j		12.9	11.1
41	20 JAN 80	1200	6.7	100.6	4.0	16.7
42	24 JAN 80	0800	0.2	321.0	5.3	11.1
43	04 FEB 80	1400	5.8	73.2	7.5	12.5
44	: 106 FEB 80	1300	11.6	267.5	14.3	11.1
45	10 FEB 80	0500	8.0	99.1	5.5	12.5
46				·	· 	
47	04 MAR 80	1800	6.2	173.9	6.3	14.4
48	10 MAR 80	2100	8.1	317.8	7.9	6.3
49	18 MAR 80	2300	5.1	278.4	9.6	12.5
50	22 MAR 80	1300	7.3	241.8	8.0	14.3
51	; 26 MAR 80	1000	9.8	295.2	9.9	14.3
52	, <del></del>			·		
53				: 		

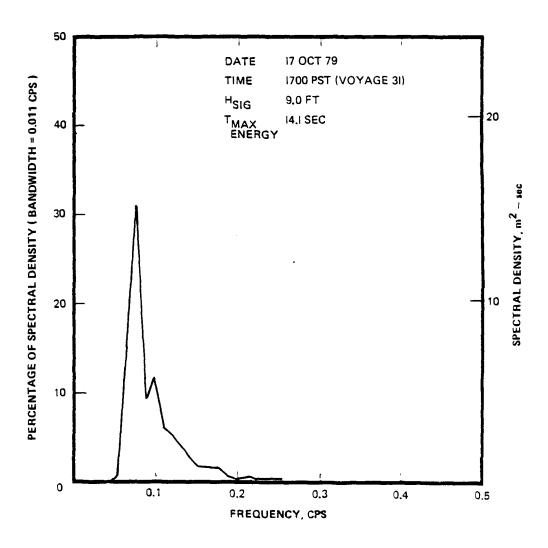
<sup>--</sup> No data available

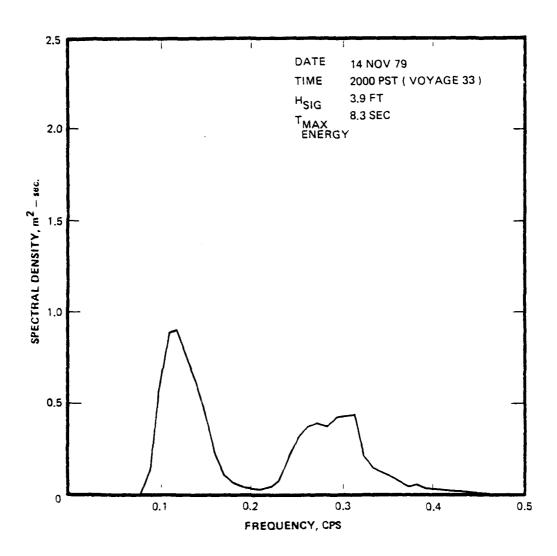


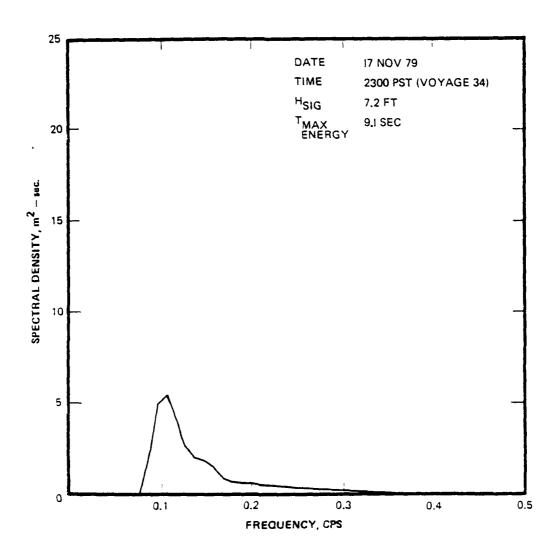


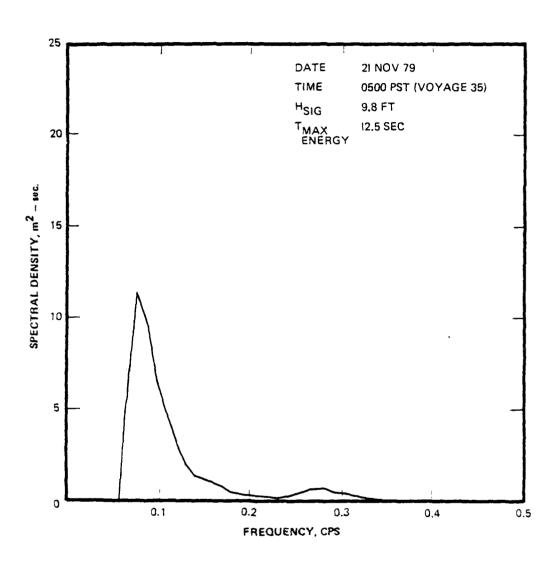


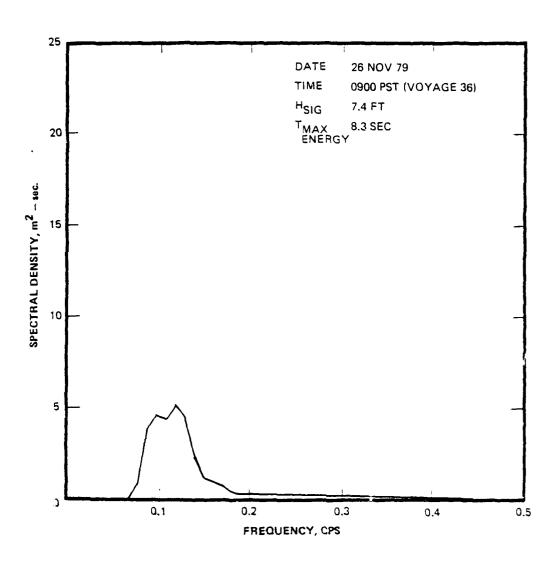




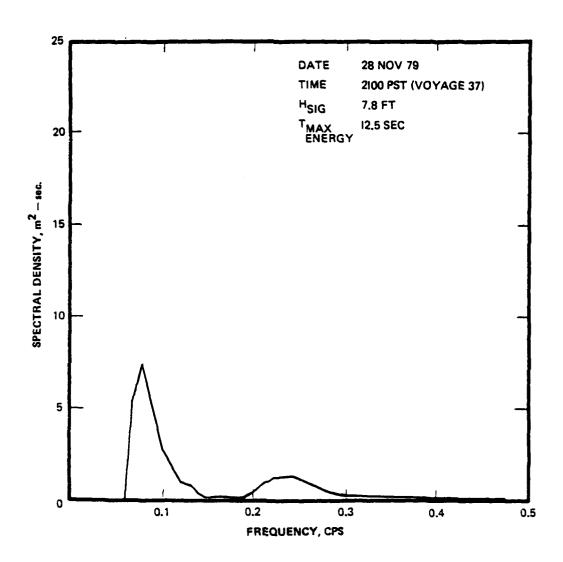


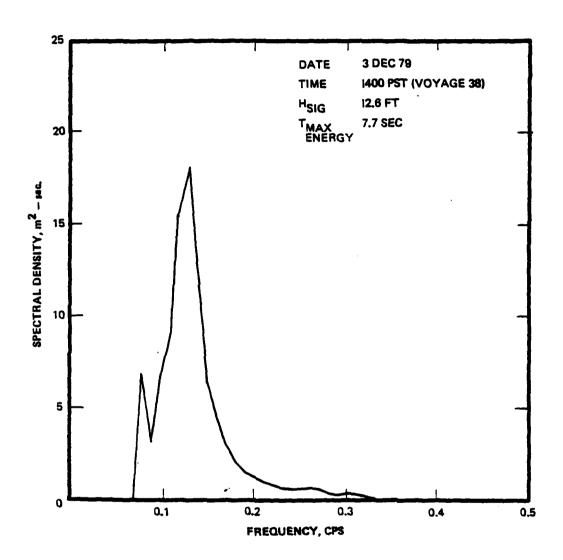


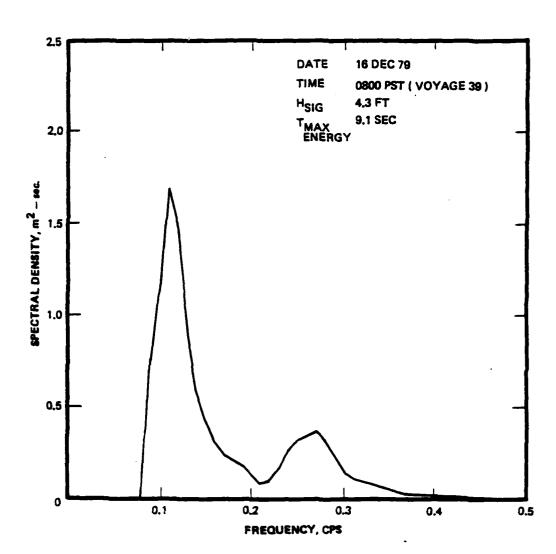


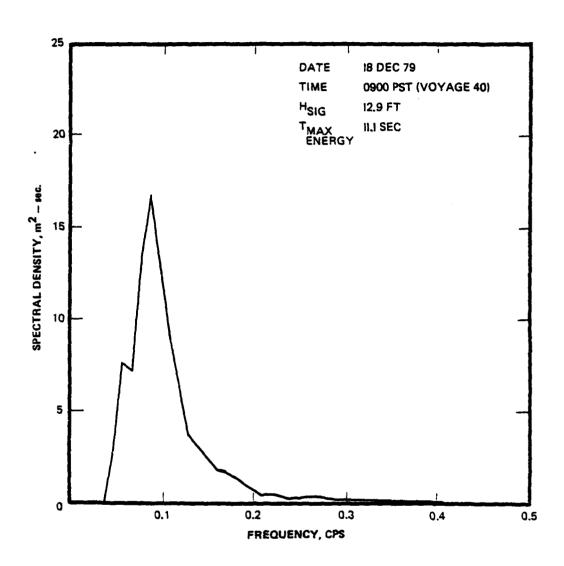


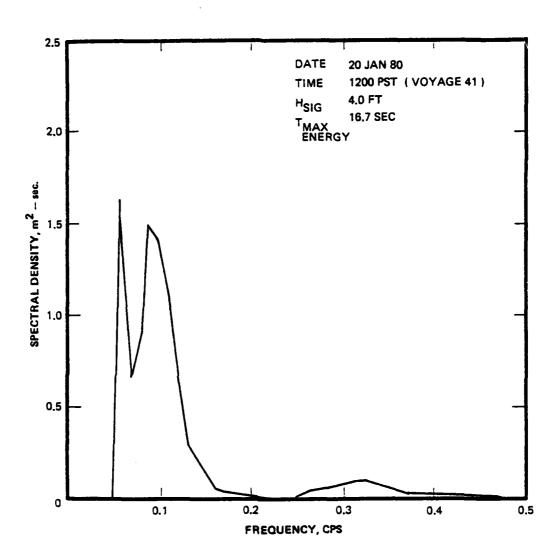
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COLUMBIA RIVER ENTRANCE CHANNEL DEEP-DRAFT VESSEL MOTION STUDY:—ETC(U)
SEP 80 S WANG, M KIMBLE, C BUTCHER, G D COX DACW57-78-C-0028
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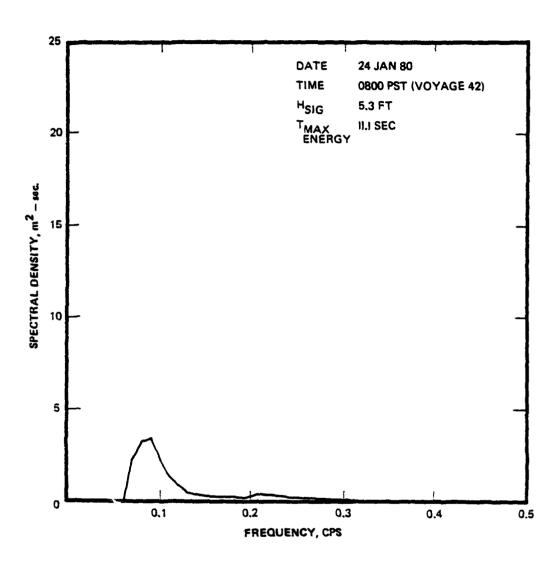


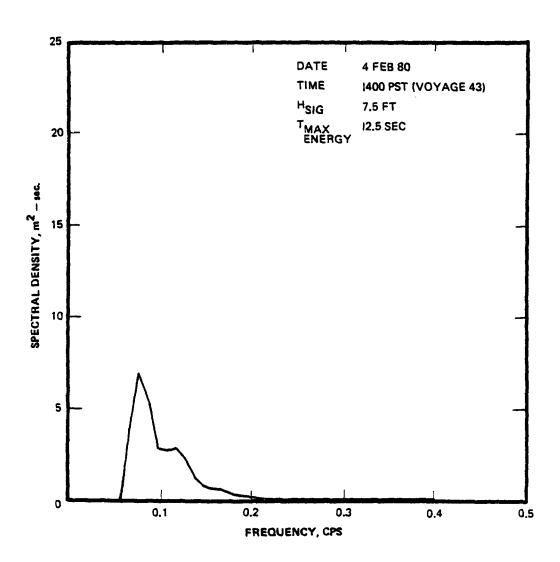


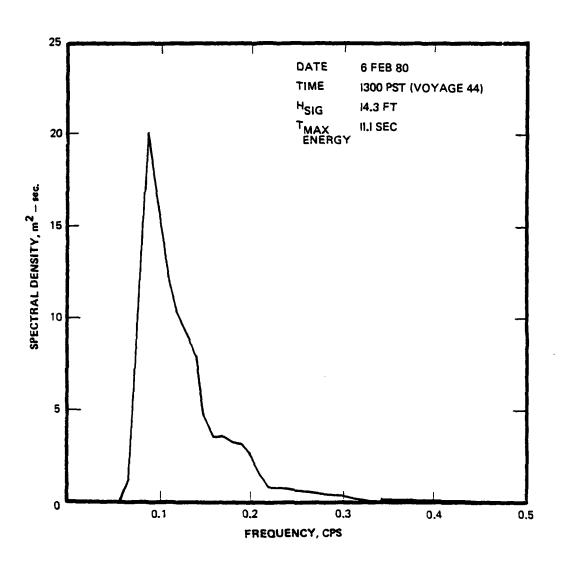


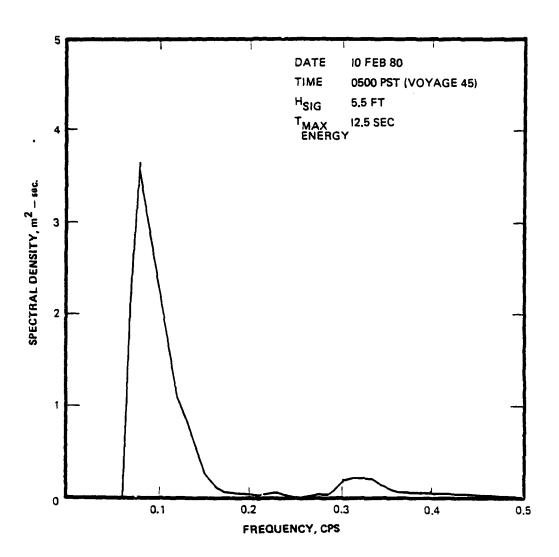


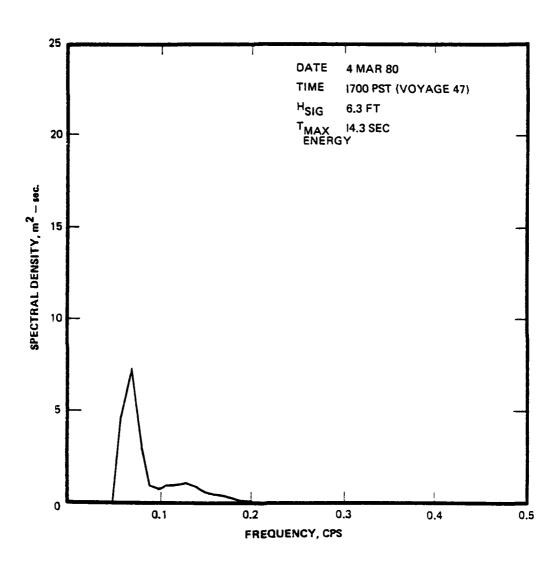


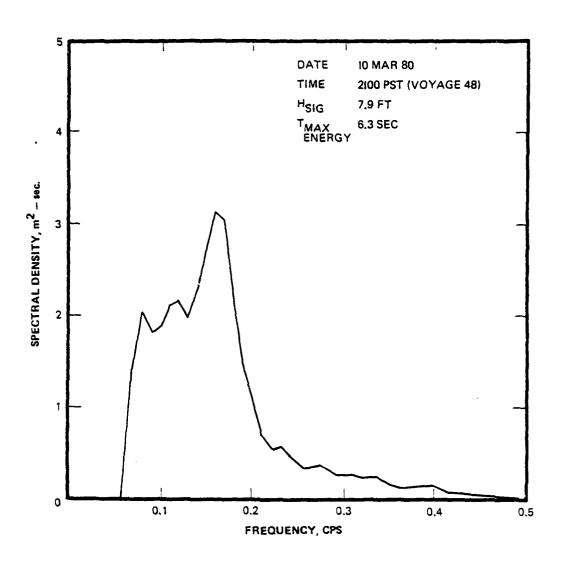


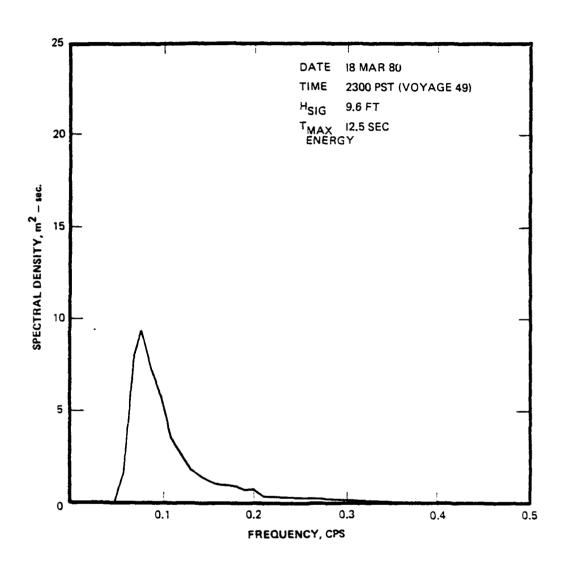


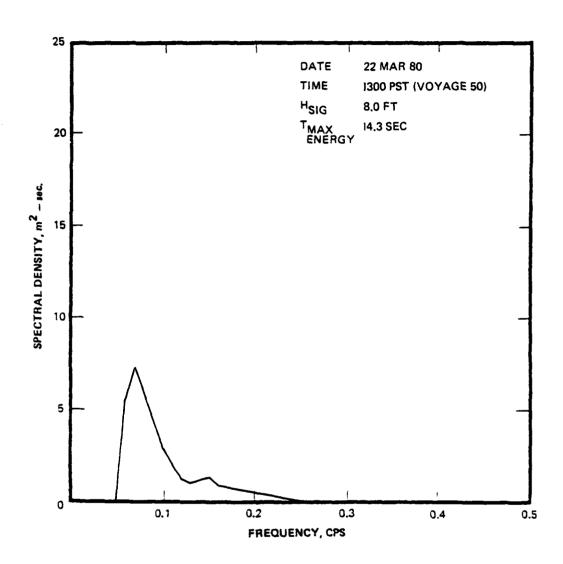


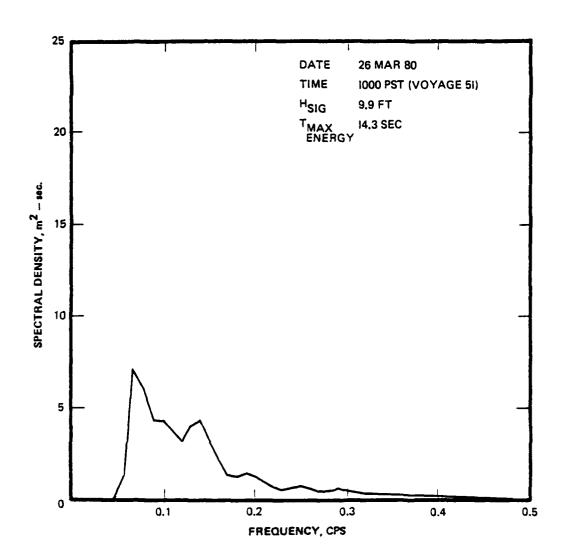












#### APPENDIX H

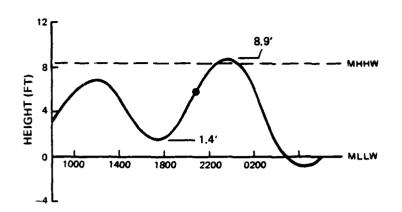
#### TIDE HYDROGRAPH AND RIVER DISCHARGE FOR EACH BAR CROSSING

- SOURCES: 1. Observed Tide Heights from National Ocean Survey (NOAA) Gauge at Astoria, Oregon
  - River Discharge Records for Vancouver, Washington from J.C. Huetter, Acting Chief, Engineering Division, U.S. Army Engineering District, Portland, May 1979, May 1980, Personal Communication.
  - 3. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, 1980: <u>Tide Tables 1979</u>, <u>High and Low Water Predictions, West Coast of North America and South America</u>.

Note: Observed tide data for April 1980 was unavailable at the time of writing. Therefore, tide hydrographs for Voyage Nos. 52 and 53 are based on predicted tide heights from source [3] cited above.

TIDE HYDROGRAPH FOR 20 – 21 MAY 1978

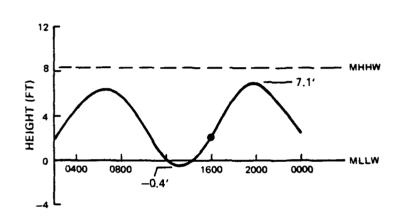
RIVER DISCHARGE = 232,000 CFS



## **VOYAGE NO. 2**

TIDE HYDROGRAPH FOR 29 ~ 30 MAY 1978

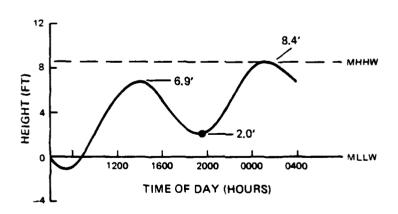
RIVER DISCHARGE = 210,000 CFS



#### **VOYAGE NO. 3**

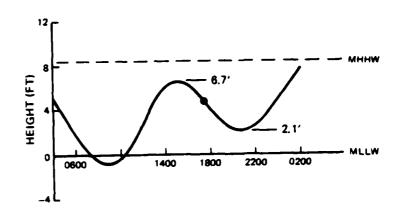
TIDE HYDROGRAPH FOR 5 – 6 JUNE 1978

RIVER DISCHARGE = 219,000 CFS



TIDE HYDROGRAPH FOR 7 – 8 JUNE 1978

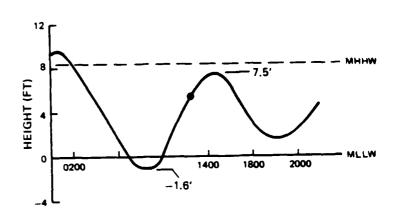
RIVER DISCHARGE = 217,000 CFS



**VOYAGE NO. 5** 

TIDE HYDROGRAPH FOR 21 JUNE 1978

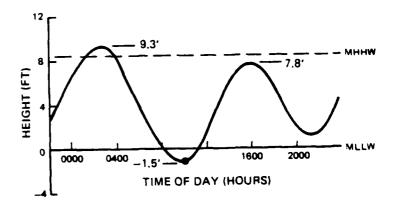
RIVER DISCHARGE = 247,000 CFS



**VOYAGE NO. 6** 

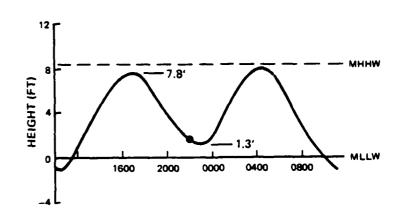
TIDE HYDROGRAPH FOR 22 – 23 JUNE 1978

RIVER DISCHARGE = 219,000 CFS



TIDE HYDROGRAPH FOR 24 – 25 JUNE 1978

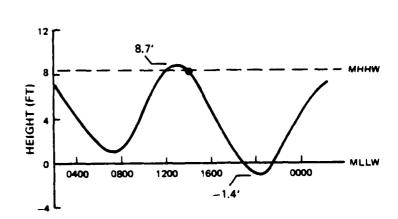
RIVER DISCHARGE = 214,000 CFS



**VOYAGE NO. 8** 

TIDE HYDROGRAPH FOR 1 - 2 NOVEMBER

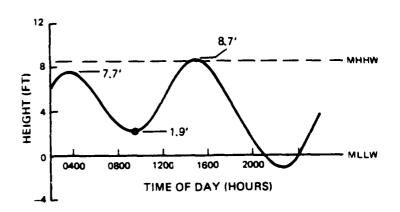
RIVER DISCHARGE = 139,000 CFS



**VOYAGE NO. 9** 

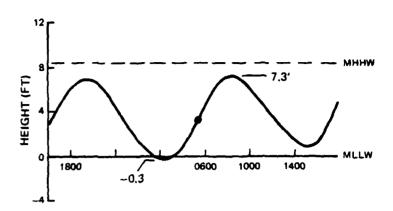
TIDE HYDROGRAPH FOR 4 - 5 NOVEMBER 1978

RIVER DISCHARGE = 166,000 CFS



TIDE HYDROGRAPH FOR 8 – 9 NOVEMBER 1978

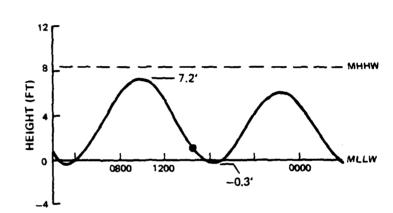
RIVER DISCHARGE = 113,000 CFS



#### **VOYAGE NO. 11**

TIDE HYDROGRAPH FOR 10 - 11 NOVEMBER 1978

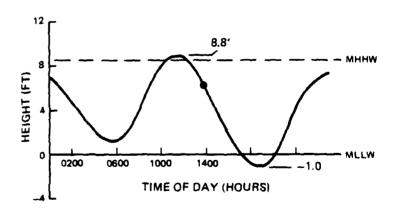
RIVER DISCHARGE = 118,000 CFS



## **VOYAGE NO. 12**

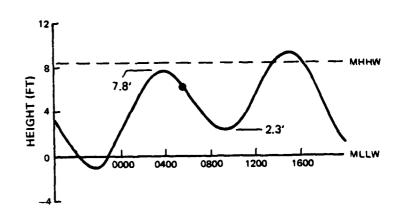
TIDE HYDROGRAPH FOR 28 – 29 NOVEMBER 1978

RIVER DISCHARGE = 190,000 CFS



TIDE HYDROGRAPH FOR 2 – 3 DECEMBER 1978

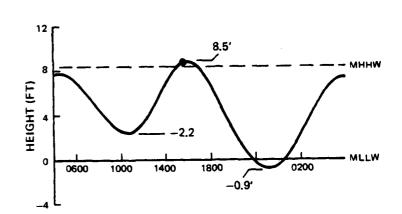
RIVER DISCHARGE = 206,000 CFS



**VOYAGE NO. 14** 

TIDE HYDROGRAPH FOR 4 - 5 DECEMBER 1978

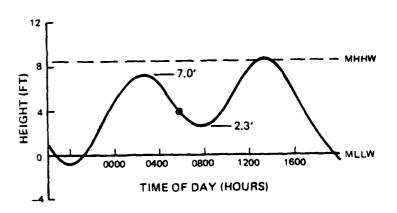
RIVER DISCHARGE = 190,000 CFS



**VOYAGE NO. 15** 

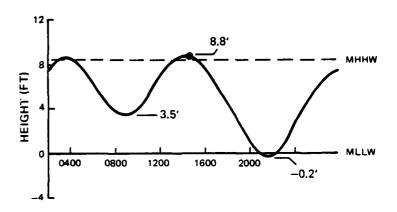
TIDE HYDROGRAPH FOR 14 - 15 DECEMBER 1978

RIVER DISCHARGE = 211,000 CFS



TIDE HYDROGRAPH FOR 17 - 18 DECEMBER 1978

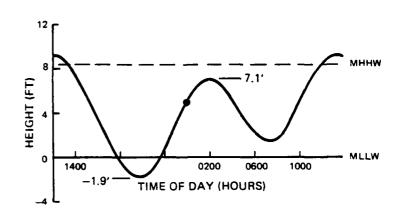
RIVER DISCHARGE = 195,000 CFS



## **VOYAGE NO. 17**

TIDE HYDROGRAPH FOR 29 - 30 DECEMBER 1978

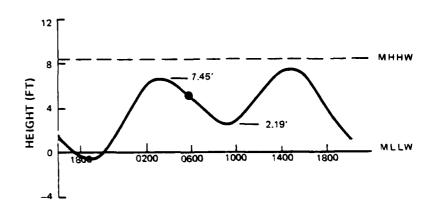
RIVER DISCHARGE = 217,000 CFS



## **VOYAGE NO. 18**

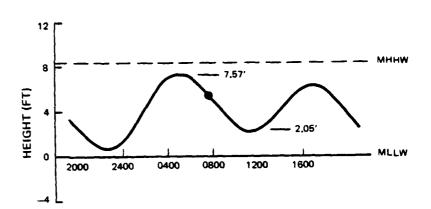
TIDE HYDROGRAPH FOR 15 – 16 JAN 1979

RIVER DISCHARGE = 195,000 CFS



TIDE HYDROGRAPH FOR 18 – 19 JAN. 1979

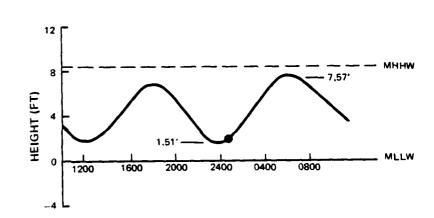
RIVER DISCHARGE = 166,000 CFS



#### **VOYAGE NO. 20**

TIDE HYDROGRAPH FOR 20 – 21 JAN. 1979

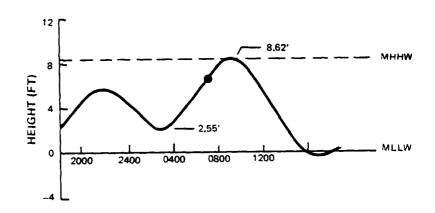
RIVER DISCHARGE = 123,000 CFS



## **VOYAGE NO. 21**

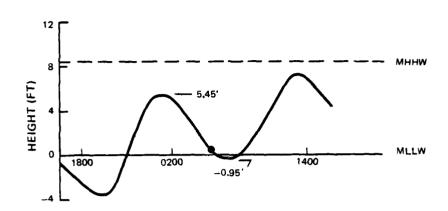
TIDE HYDROGRAPH FOR 23 – 24 JAN. 1979

RIVER DISCHARGE = 201,000 CFS



TIDE HYDROGRAPH FOR 27 – 28 JAN. 1979

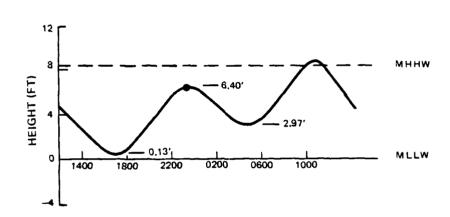
RIVER DISCHARGE = 155,000 CFS



#### **VOYAGE NO. 23**

TIDE HYDROGRAPH FOR 07 - 08 FEB. 1979

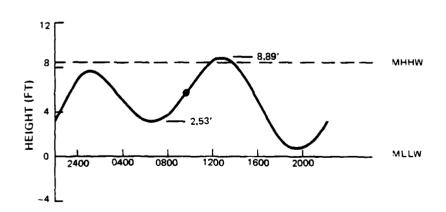
RIVER DISCHARGE = 212,000 CFS



# **VOYAGE NO. 24**

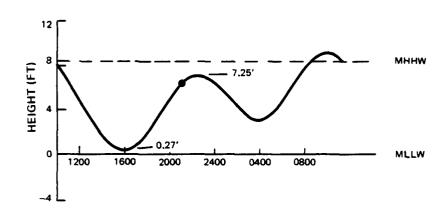
TIDE HYDROGRAPH FOR 10 - 11 FEB. 1979

RIVER DISCHARGE = 277,000 CFS



TIDE HYDROGRAPH FOR 22 – 23 FEB. 1979

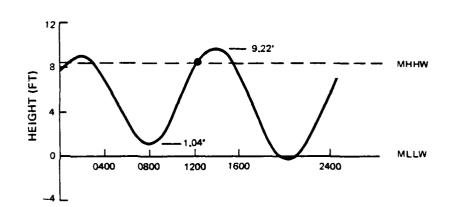
**RIVER DISCHARGE - 202,000 CFS** 



## **VOYAGE NO. 26**

TIDE HYDROGRAPH FOR 27 FEB. 1979

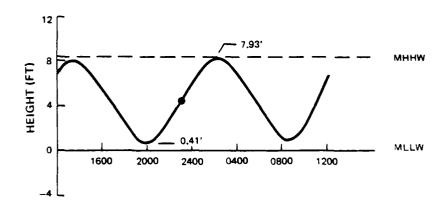
RIVER DISCHARGE = 242,000 CFS



# **VOYAGE NO. 27**

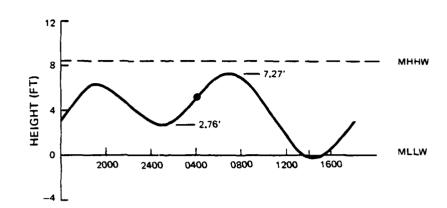
TIDE HYDROGRAPH FOR 14 – 15 MAR. 1979

RIVER DISCHARGE = 211,000 CFS



TIDE HYDROGRAPH FOR 21 – 22 MAR. 1979

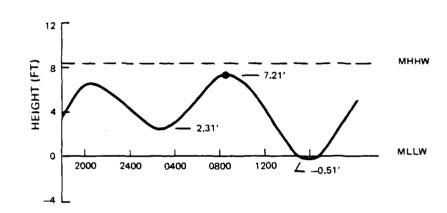
RIVER DISCHARGE = 179,000 CFS



## **VOYAGE NO. 29**

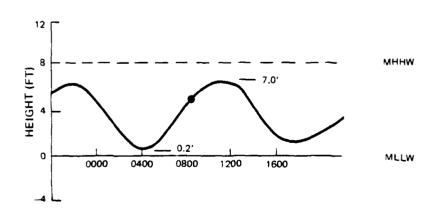
TIDE HYDROGRAPH FOR 22 – 23 MAR. 1979

RIVER DISCHARGE = 184,000 CFS



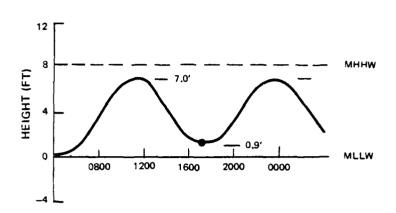
## **VOYAGE NO. 30**

TIDE HYDROGRAPH FOR 15 - 16 OCTOBER, 1979 RIVER DISCHARGE = 113,000 CFS



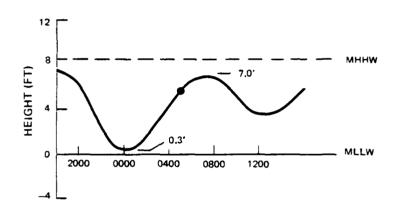
TIME OF DAY (HOURS)

TIDE HYDROGRAPH FOR 17 - 18 OCTOBER, 1979 RIVER DISCHARGE = 111,000 CFS



## **VOYAGE NO. 32**

TIDE HYDROGRAPH FOR 27 - 28 OCTOBER, 1979 RIVER DISCHARGE = 121,000 CFS

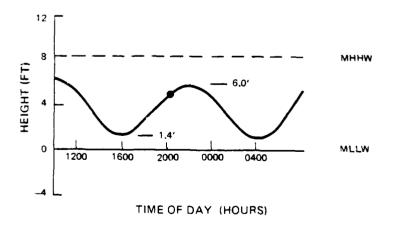


## **VOYAGE NO. 33**

TIDE HYDROGRAPH FOR

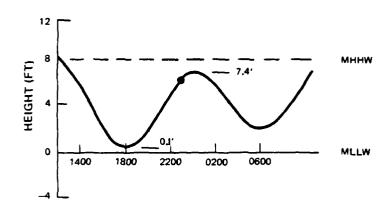
14 - 15 NOVEMBER, 1979

RIVER DISCHARGE = 108,000 CFS



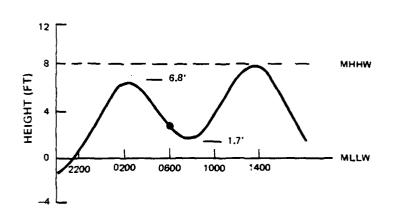
TIDE HYDROGRAPH FOR 17 - 18 NOVEMBER, 1979

RIVER DISCHARGE = 155,000 CFS



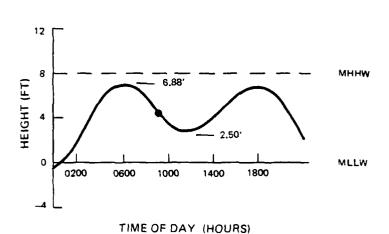
**VOYAGE NO. 35** 

TIDE HYDROGRAPH FOR 20 - 21 NOVEMBER, 1979 RIVER DISCHARGE = 155,000 CFS

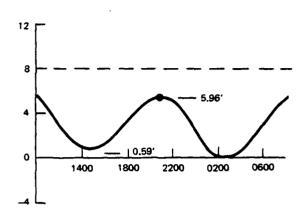


**VOYAGE NO. 36** 

TIDE HYDROGRAPH FOR 26 NOVEMBER, 1979 RIVER DISCHARGE = 164,000 CFS

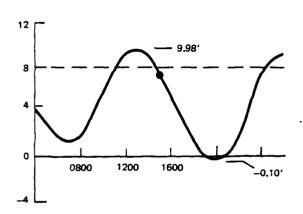


TIDE HYDROGRAPH FOR 28 – 29 NOVEMBER, 1979 RIVER DISCHARGE = 174,000 CFS



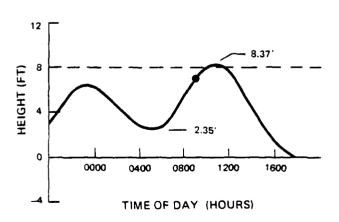
# **VOYAGE NO. 38**

TIDE HYDROGRAPH FOR
3 – 4 DECEMBER, 1979
RIVER DISCHARGE= 225,000 CFS

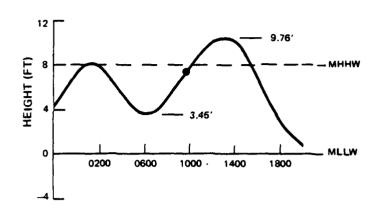


## **VOYAGE NO. 39**

TIDE HYDROGRAPH FOR 15 - 16 DECEMBER, 1979 RIVER DISCHARGE = 169,000 CFS

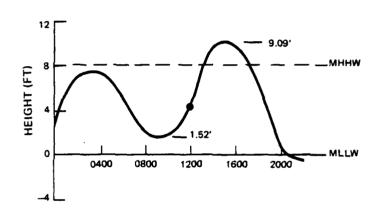


TIDE HYDROGRAPH FOR 17 - 18 DECEMBER, 1979 RIVER DISCHARGE = 203,000 CFS



## **VOYAGE NO. 41**

TIDE HYDROGRAPH FOR 20 JANUARY, 1980 RIVER DISCHARGE = 279,000 CFS

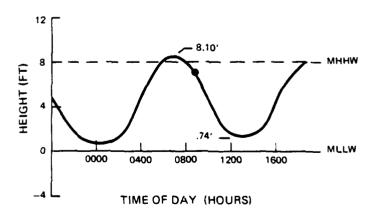


## **VOYAGE NO. 42**

TIDE HYDROGRAPH FOR

23 - 24 JANUARY, 1980

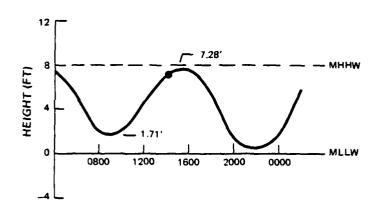
RIVER DISCHARGE = 206,000 CFS



TIDE HYDROGRAPH FOR

4 - 5 FEBRUARY, 1980

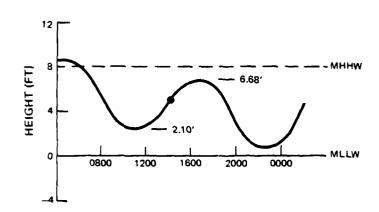
RIVER DISCHARGE = 201,000 CFS



## **VOYAGE NO. 44**

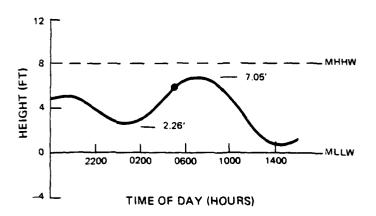
TIDY HYDROGRAPH FOR 6 – 7 FEBRUARY, 1980

RIVER DISCHARGE= 166,000 CFS



## **VOYAGE NO. 45**

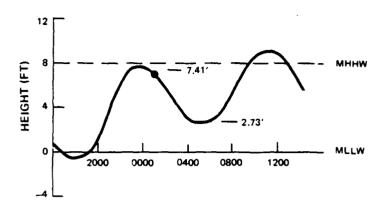
TIDE HYDROGRAPH FOR 09 - 10 FEBRUARY, 1980 RIVER DISCHARGE = 139,000 CFS



TIDE HYDROGRAPH FOR

13 - 14 FEBRUARY, 1980

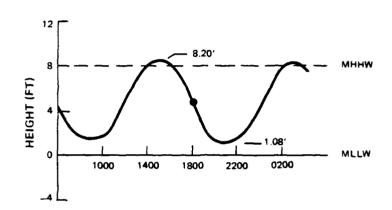
RIVER DISCHARGE = 203,000 CFS



## **VOYAGE NO. 47**

TIDE HYDROGRAPH FOR 4 - 5 MARCH, 1980

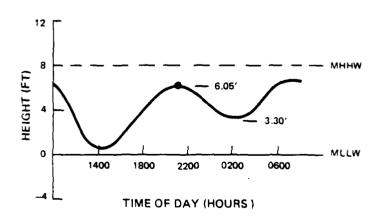
RIVER DISCHARGE = 201,000 CFS



#### **VOYAGE NO. 48**

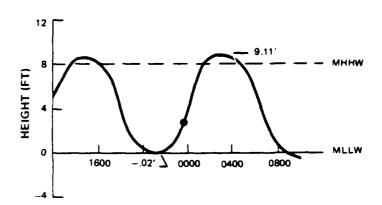
TIDE HYDROGRAPH FOR 10 – 11 MARCH, 1980

RIVER DISCHARGE = 128,000 CFS



TIDE HYDROGRAPH FOR 18 – 19 MARCH, 1980

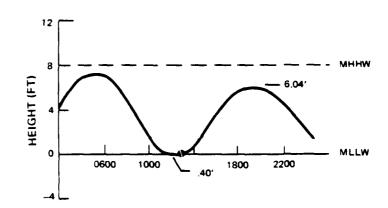
RIVER DISCHARGE = 255,000 CFS



**VOYAGE NO. 50** 

TIDE HYDROGRAPH FOR 22 MARCH, 1980

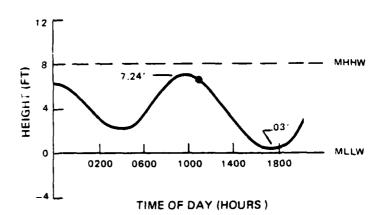
RIVER DISCHARGE = 1640,000



**VOYAGE NO. 51** 

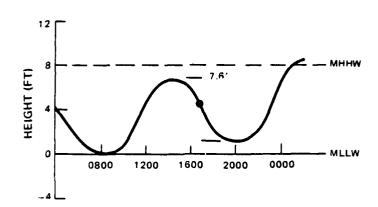
TIDE HYDROGRAPH FOR 25 – 26 MARCH, 1980

RIVER DISCHARGE = 128,000 CFS



TIDE HYDROGRAPH FOR 1 – 2 APRIL, 1980

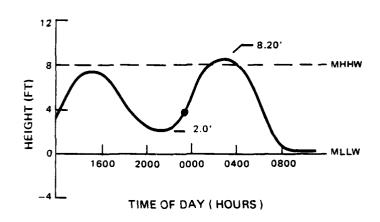
RIVER DISCHARGE = 171,000 CFS



**VOYAGE NO. 53** 

TIDE HYDROGRAPH FOR 3 – 4 APRIL, 1980

RIVER DISCHARGE = 179,000



APPENDIX I
ENCOUNTER PERIODS BASED ON OBSERVED WAVE DATA

ENCOUNTER PERIOD BASED ON OBSERVED WAVE DATA (Phase I)

VOYAGE	SHIP SPEED (Kts)	SHIP'S COURSE MADE GOOD (Deg)	OBSERVED SWELL DIRECTION (Deg)	ANGLE OF INCIDENCE 3 (Deg)	OBSERVED SWELL PERIOD (Sec)	ENCOUNTER PERIOD (Sec)
1	10	44.5	315	90.5	8	8.0
2	12.5	44.1	270	45.9	. 8	12.5
3∆	13		270		9	<del></del> )
4	14	43.7	247.5	23.8	9	17.0
5	13	46.2	292.5	66.3	8	10.2
6	14	48.0	315	87.0	8	8.3
. 7	14	221.6	292.5	109.1	7	5.8
$8^{\Delta}$	11		315		11	
, 9	13.5	222.9	292.5	110.4	10	8.7
10	13	42.4	315	92.6	8	7.8
11	15	225.9	315	90.9	8	7.9
12	15	54.9	247.5	12.6	8	20.2
13 <sup>2</sup>	13	42.9	270	47.1		
142	11.5		292.5		9	
15	8	44.2	270	45.8	8	10.4
16	6	226.9	270	136.9	3	6.3
172	17	46.9				
18	. 13	43.4	292.5	69.1	9	9.9
19	8	223.9	270	133.9	10-11	8.9
20	17	43.9	247.5	23.6	10-11	20.6
21	17	45.1	337.5 270	112.4 44.9	8-10 3	7.3 15.9
22	17	44.4	292.5	68.1	10	12.6
23	18.5	49.3	270	40.1	10	18.8
24	16	55.8	202.5	33.3	3	17.8
25 <sup>4</sup>	17		202.5		3	
26	16	52.3	225 270	7.0 38.0	3 10	23.2 17.1
27	15	44.7	270	45.3	13	15.3
28	13	45.9	292.5	56.5	10	12.1
29 <sup>-</sup>	10.5		270		10	

Data unavailable

 $P_{e} = \frac{T}{2T} (0.59217 \cos 3) \text{ where } P_{e} = \text{encounter period sec}$  T = wave period sec T = ship's speed knots T = ship's speed knots T = ship's speed knots

ENCOUNTER PERIOD BASED ON OBSERVED WAVE DATA (Phase II)

voyage number	SHIP SPEED (Kts)	SHIP'S COURSE MADE GOOD (Deg)	OBSERVED SWELL DIRECTION (Deg)	ANGLE OF INCIDENCE 3 (Deg)	OBSERVED SWELL PERIOD (Sec)	ENCOUNTER PERIOD (Sec)
30	14	43.6	315	91.4	8	7.9
31	10	226.7	270	136.7	8	6.2
32	16	49.7	270	40.3	10	16.7
33	14	52.8	270	37.2	10	15.8
34	14	222.6	270	132.6	9	6.7
35	13	225	225	180	8-10	6.1
36	17	68.6	270	21.4	8	23.0
37	14	57.1	270	32.9	10	16.3
38	14	223.8	180	136.2	6-7	4.3
39	13	44.9	270	45.1	8	12.9
40	. 12	231.5	225	173.5	8	5.4
412	14		202.5		8-10	
42	17	44.5	292.5	68	13	15.5
43	15	50.7	270	39.3	10	16.2
44	8	230.5	270	140.5	3	ó.4
45 <sup>±</sup>	14		270		10	
46	14	221.3	225	176.3	8-10	ź. J
47	13	45.4	292.5	57.1	3-10	11.1
48	12	47.3	275	4.3	3-9	12.9
49-	14		270		13	
50	14	225.0	292.3	112.5	12-13	11.0
51	14	44.7	292.3	67.8	5 <b>-</b> 3	¥.3
52	16	42.3	292.5	70.2	1.	14.1
53	14	49.6	270	40.4	<b>3-</b> 10	15.1

APPENDIX J
STRIP CHART RECORDINGS OF RUDDER DFFLECTIONS
FOR VOYAGE NOS. 30 AND 31

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# RUDDER ANGLE & Course Record

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APPENDIX K
PLOTS OF SHIP MOTION SPECTRA FOR SELECTED VOYAGES

